6. The Development of Intelligence

The unfortunate result of mixing science and politics in the field of intelligence has been a tendency to focus on peripheral or subsidiary issues before the basic ones have been resolved. As a result, there has been a great deal of debate on such issues as the relative effects of heredity and environment on intelligence, race-related differences in intelligence, and social-class differences in intelligence – all in the absence of any good underlying theory of just what intelligence is.

–Robert J. Sternberg[1]

Intelligence is what the tests test.

–Edwin G. Boring[2]

Do Psychologists Know What Intelligence Is?

Lay people believe that intelligence amounts to brainpower, or how "smart" a person is, yet over the years since Alfred Binet and Theodore Simon created the first test of intelligence (Binet & Simon, 1905) psychologists have proposed numerous differing definitions of intelligence. Exactly what intelligence is and how it should be measured is an ongoing controversy that continues to this day. Thus, before considering how intelligence develops, it is important to take a close look at some of these many different views of intelligence and the changing ideas about this construct.

The question "Do we know what intelligence is?" is therefore difficult to answer (note the opening quotes, above), and clearly, psychologists have always had many different ideas about this.

The Nature of Intelligence: A Personal Reflection by the Author

When I was a student in junior high school (now known in the U.S. as "middle school") we were routinely tested for not only

achievement, but also for intelligence. It was a poorly kept secret that the middle three numbers in one's identification code that appeared on official records represented one's score on an intelligence test, which was referred to (incorrectly, as will be seen) as intelligence quotient, or IQ. This number was thus available to both teachers and to school administrators. Given this IQ score along with standardized achievement scores, decisions were made regarding a student's placement, on the assumption that these scores directly reflected one's presumed academic abilities.

I was disheartened to learn in the seventh grade that my IQ was hopelessly average, despairing because I never wanted to be "merely" average. As I had a rather low self-image already this made me feel depressed. Why? For one thing, we students tended to believe that IQ was a fixed property of an individual. It was a numeric summary of just how smart one was (or was not, as the case might be). As an average student, I could only expect to have an average career; I would never be outstanding in anything I attempted in later life. I just wasn't smart enough!

Routine intelligence testing later became quite controversial. One of the many reasons for the controversy was that IQ scores were greatly misunderstood – not only by students, but by parents and teachers as well. There was indeed a misconception among some, and even among professionals, in that they (like me at the time) often tended to reify intelligence; to assume it represented something "real" in the mind; something that was fixed and unchanging. The negative result was that it tended to stereotype people. A person's IQ score could be used as a convenient label for assessing everything from a student's likely potential grade in a given course to assumptions about his or her future expectations in life. Students might then be further labeled as "over-" or "underachievers," depending on how well they actually performed in their class work when compared to their expected potentials based on their IQ scores.

On a happier personal note, it was much, much later in life – when I was a Ph.D. student, in fact – that I took a carefully administered individualized test, and found my IQ "number" to be higher (in fact, incredibly so!). The measurement taken in youth, as it turned out, was clearly a poor predictor of my later score. But by

this time, I had learned enough psychology not to take the score quite so seriously. I now understood that IQ scores were not fixed and unchanging; that a given score (especially on a group test) could vary considerably from day to day depending on a number of factors; and that scores could greatly increase (or in fact, decrease) over long periods of time.

I also came to realize that intelligence does not necessarily represent just one kind of ability!

My story is by no means unique. Robert J. Sternberg is one of the most respected and recognized names in intelligence research today. He performed poorly on his intelligence test in the sixth grade – so poorly that he was asked to retake the test with the fifth grade class, where the test was considered easier. Sternberg has written numerous books and over 800 articles in a number of areas of psychology, including intelligence, and is a past president of the American Psychological Association.

Intelligence was then, and still is, a frightfully misunderstood construct. Misconceptions about the nature of intelligence, what it means, and what psychologists actually measure with intelligence tests, still abound today.

Intelligence – Is it One Ability or Many?

A Definition of Intelligence

David Wechsler designed some of the most widely regarded intelligence tests in use today, including the Wechsler Adult Intelligence Scale (WAIS-IV) and the Wechsler Intelligence Scale for Children (WISC-V). He defined intelligence as *the global ability to think rationally, act purposefully, and deal effectively with the environment* (Wechsler, 1944). This definition is satisfactory to many psychologists in a very general sort of way, but still, it may not go far enough. Disagreements still abound as to exactly what intelligence is, and of equal importance, what it is not. For other definitions that have been proposed (and there are many) see Sternberg and Determan (1986).

To further clarify the concept, perhaps it will help to specify what intelligence is *not*. By any good definition, intelligence is not a "thing" – it is not, for instance, a physiological structure located in some specific, identifiable location in the brain. According to Wechsler, intelligence is an overall or global kind of mental ability, but to other researchers it consists of many distinct kinds of mental abilities. Indeed, one of the first and most persistent controversies among psychologists studying intelligence is the issue of the nature and number of cognitive abilities that actually comprise intelligence.

How Many Factors of Intelligence Makes Sense?

Spearman's g. Early in the history of intelligence testing, a British psychologist who was also highly skilled in statistics, Charles Spearman (e.g., Spearman, 1904), recognized that a given individual might be better at one sort of mental skill than another. However, he also believed that intelligence was best understood as a single, global ability that underlies all such cognitive skills. Spearman referred to this ability as ***g*** as in *general* intelligence. He theorized that each test or subtest in an intelligence test battery measured both *g* and a separate component representing an ability that is specific to that particular test.

Spearman used a statistical method known as ***factor analysis*** to try to prove his point. Factor analysis analyzes the intercorrelations among all measures (usually subtests) and identifies a smaller number of linear (statistical) combinations of the variables called ***common factors*** (or more simply, just ***factors***). For example, a researcher might begin with a battery of 20 tests, then finds that a smaller number of factors – say 5 or 6 – accounts for most of the common (or overlapping) covariation that is mutually shared by these tests. Interpretation of the factors then follows. Interpretation is made easier when there is only indeed only one general factor, based on a large degree of overlap among all the tests – as was the case with Spearman's early work in which he hypothesized that such a single general factor would emerge. However, his sample of tests was somewhat limited, and other researchers disagreed with his interpretations.

Thurstone's Primary Mental Abilities. Louis Leon Thurstone, an American psychologist who, like Spearman, developed his own statistical methodology, further refined the method of factor analysis. Using these methods he identified seven separate factors which he called ***group factors***. These group factors represented ***primary mental abilities*** for Thurstone (1938), which were very general, and stood for qualitatively different kinds of mental skills (see Table 5.1 for a description of these). Although Thurstone's factors were correlated to a certain degree, he considered them quite basic and fundamental. In other words, primary mental abilities went beyond *g*, and intelligence was a multidimensional construct to Thurstone. But other researchers using different rationales have proposed differing numbers of factors or abilities – as many as 120 in J. P. Guilford's (1967) structure of the intellect model! Although Guilford's very large number of factors has not been well accepted in the field of psychology, researchers do still differ with respect to the "correct" number of mental abilities – should it be one, two, seven, or more?

There are problems with using factor analysis as the sole basis for deciding on the number of cognitive abilities that define intelligence. First, factors are based on correlational procedures designed to uncover regularities or consistencies of pattern in data. Reliably identifying a factor does not by itself prove that one has discovered some sort of unique underlying mental process. Factor analysis is a starting point rather than a terminal one in investigating the nature of intelligence.

Second, although certain objective criteria can be applied to determine the presumed "correct" number of factors, the application of different rules by different researchers results in differing numbers of factors. Third, and related to both of the previous points, is the question of whether a factor represents a major or a minor sort of ability: the more factors that one extracts, the less likely one is to find that the identified abilities represent very general or basic kinds of processes. And fourth, different batteries involve different numbers and kinds of tests, and the composition of one particular battery will result in a different number of factors than will some other set.

Table 5.1
Thurstone's Seven Primary Mental Abilities

Factor	Brief Description
Verbal Comprehension	Vocabulary; understanding of words
Verbal Fluency	Verbal facility, such as anagram problems or word categories
Number	Arithmetic facility
Spatial	Manipulation of objects in space, such as mental rotation
Associative Memory	Simple rote memory tasks
Perceptual Speed	Speed in identifying visual details, as in clerical tasks
Inductive Reasoning	Problem solving by finding best "rules," as in number series (e.g., "what is the next number in this series?")

Hierarchical Models. Hierarchical models of mental abilities can be seen as bridging the gap between those favoring one, a few, or many factors of mental abilities. In developing hierarchical models, researchers first extract a relatively large number of factors – perhaps 10 to 20, for example. The correlations among these basic or ***first-order*** factors are themselves subjected to factor analysis and a fewer number of ***second-order*** factors are extracted. The process is repeated recursively, until just one or two factors at a higher order are uncovered and no further factors can be extracted. In practice, one is usually left with a single, third-order factor of general intelligence, perhaps two second-order factors,

and many first-order factors. The number of factors problem then becomes less critical; instead, one decides on the appropriate *level* of analysis for a given research endeavor: one, two, or several may be of practical interest.

Raymond B. Cattell developed such a model (Cattell, 1963, 1987). His two second-order factors were called ***crystallized intelligence*** and ***fluid intelligence***. Crystallized intelligence, Cattell believed, greatly depends on learning and is therefore partially a function of culture (nurture), whereas fluid intelligence is largely nonverbal, and relatively less dependent on culture – it is therefore more likely to be influenced by heredity (nature). John Horn (1994) has revised and extended Cattell's model (now called the Horn-Cattell theory of intelligence). A similar hierarchical model was proposed by Philip E. Vernon (1950/1971). Vernon's two second-order factors were called ***practical-mechanical*** and ***verbal-educational***.

Sternberg's Critique of the Psychometric Approach. Robert Sternberg (1988) called the factor analytic approach to understanding intelligence the geographical or mental map approach – a concept that he considers limited. Although factor analysis certainly ought to be applied to any new kind of intelligence test battery, it is only one step in the process in theorizing about the nature and nature of underlying mental abilities. Much of the work on intelligence in the latter part of the twentieth century focused on ***information processing***, or the study of mental processes and strategies employed by different individuals, when solving problems. The information processing approach is, indeed, in the spirit of Piaget – recall from Chapter 4 that Piaget was not at all concerned with whether or not a child got a correct answer on an intelligence test item, but rather, with how that child arrived at the particular answer. But before leaving the number of factors issues, a couple of additional approaches will be considered. It is also important to recognize that many useful predictions can be made from intelligence tests based on either total scores, or from scores on the several group factors. Academic achievement, for instance, is statistically predictable from overall

intelligence scores. But is success in life? This issue will be addressed a little further on.

Gardner's Multiple Intelligences. Howard Gardner (1983, 1993) argued for several different kinds of intelligence. He based his ideas not on statistical factor analysis, but rather, on psychology's limited (but growing) knowledge of how the human brain functions. He considered, among other factors, what could be learned from limited brain functioning in brain damaged individuals, as well as information processing capabilities identified in the study of children's learning that are linked to sensitive or critical periods of development. Gardner also derived some of his concepts of intelligence from the study of individuals known as ***savants***. Such people are very gifted in one, limited area, but are also slow or retarded in others, which suggested that some mental abilities are relatively independent of others. Leslie Lemke, born blind, mentally retarded, and with cerebral palsy, is a musical genius at the piano. By the time he was a teenager he could play the most complicated musical arrangements by ear, often after having heard them for only one time (Beirne-Smith and others, 2005). Some severely autistic children are very good at certain kinds of mathematical calculations; in fact, they are geniuses in their own limited realms. The character of Raymond (played by Dustin Hoffman in the feature film *Rainman*, based on a true story), was also such an individual.

Gardner fully acknowledged that his ideas are formative and ongoing, and subject to revision as psychology and neuroscience learn more about the development and functioning of the brain.

Based on his own evaluations of current research, he identified eight separate kinds of intelligence. The first three of these are not unlike traditional, psychometric factors, which include: ***verbal*** or linguistic, ***logical-mathematical***, and ***spatial***. The remaining five are quite untraditional though. They include: ***musical, bodily-kinesthetic*** (highly developed in dancers and athletes, for example), ***interpersonal*** (social skills; knowledge of others), ***intrapersonal*** (self-awareness and cognitions about oneself), and ***naturalistic*** (sensitivity to, or appreciation of, nature).

Obviously, some of Gardner's dimensions of intelligence differ greatly from those identified through psychometric analyses of standard intelligence tests. Some psychologists believe that certain of these dimensions really represent specialized talents, but not intelligence, the definitions of which are ordinarily couched in more cognitive terms. But arguably, all of these abilities may ultimately be related to brain functions, at least in theory, and Gardner also notes that all are valued abilities not only in our culture but also in most others as well.

Sternberg's Triarchic Theory of Successful Intelligence. Recalling from above that Sternberg had difficulty "passing" intelligence tests in grade school, there is some irony in the fact that he is perhaps *the* leading authority today on that subject! Sternberg and Gardner are in agreement that traditional concepts of intelligence are inadequate on both theoretical and methodological grounds. Sternberg viewed some of Gardner's aspects of intelligence more as specialized abilities rather than what is meant traditionally by "intelligence," but both agree on the limitations of the psychometric approach.

Successful intelligence for Sternberg means not only success in school (although that is part of intelligence), but also success in life. His (Sternberg, 1985; 1997) ***triarchic theory of successful intelligence*** (triarchic connoting three distinct aspects) consists of:

- ***Analytic intelligence:*** This is the kind generally measured by IQ tests – the ability to solve various kinds of abstract problems. People who are high in this ability tend to do best in academics (at least if motivated to do so), but it is much less predictive of success on the job or in life generally.

- ***Creative intelligence:*** This pertains to the way in which people adapt to new situations. People who are creatively intelligent do draw on past experience and learning, but they are able to solve problems in novel ways.

- ***Practical intelligence:*** This aspect of intelligence refers to the capacity to adapt – as such it comes close to David Wechsler's definition cited earlier, which is an ideal often cited by psychologists, yet somehow never adequately measured (certainly not by traditional tests of intelligence). A vernacular term one often sees for this type of intelligence is "street smarts." What is seen as practical intelligence in one culture may differ from another, but there is always an emphasis on successful adaptation.

Sternberg provided some intriguing commentary on race, intelligence, and culture in his presidential address to the American Psychological Association. He reminded psychologists that in the early days of IQ testing, "A leading researcher, Henry Goddard, pronounced that 79% of immigrant Italians were 'feeble-minded'; he also asserted that about 80% of immigrant Hungarians and Russians similarly lacked intelligence . . . [he] associated moral decadence with this deficiency of intelligence . . . And he declared that all potential immigrants with low scores should be selectively excluded from entering the United States . . . Today, Italian American students who take IQ tests show slightly above average IQs [they should be about "average" according to definition]; other immigrant groups that Goddard . . . denigrated have shown similar 'amazing' increases . . . Cultural assimilation, including integrated education and adoption of American definitions of intelligence, seems a much more plausible explanation" (2004, p. 336).

On race and intelligence, Sternberg, Grigorenko, and Kidd (2005) state: ". . . the overwhelming portion of the literature on intelligence, race, and genetics is based on folk taxonomies rather than on scientific analysis . . . Race is a social construction with no scientific definition . . . No gene has yet been conclusively linked to intelligence . . . The authors also show that heritability, a behavior-genetic concept, is inadequate in regard to providing such a link" (2005, p. 46). Here Sternberg and his colleagues do not deny that genetics plays a role in intellectual potential; but like so many others, they see "race" as a socially constructed construct

that lacks any sort of empirical validity; hence purported links of "race" and IQ are essentially not viable constructs.

The Case for Multiple Factors of Mental Ability: Two Individual Histories

Ledyard Tucker has been called the "world's wisest psychometrician" (Kaiser, 1970). (A psychometrician is one whose expertise lies in mathematical methods pertaining to psychological assessment techniques and testing). Although not well known to the general public, Tucker, a protégé of Louis L. Thurstone early in his career, is an icon to psychologists who studied in the field of psychological testing (including the present author).

In an interview with Neil J. Dorans (2004), Tucker, who at the time was 93 years old, recounted some of the highlights of his career. Dorans asked Tucker where his strong and superb spatial reasoning skills came from. He replied that he "was always a poor student in the linguistic areas. I did poorly in school until we began to do mathematics. Up to that point most class work involved reading and spelling, which was hard for me. When we started doing mathematics in high school I began to do very well (p. 146)."

Tucker did some remarkable work in high school chemistry lab, where he "simulated production of compounds that were produced in chemical factories . . . I also received a National Honor Society award for my work in science as a high school student (p. 146)." And Tucker received many other awards and honors as a student.

According to Tucker, "One thing that struck me immediately was the wisdom of Thurstone's multfactor perspective on human abilities . . . I am poor at linguistics, which made it hard for me to get my points across. On the other hand, I am strong with respect to quantitative and spatial abilities. My own pattern of abilities supported Thurstone's perspective about the multi-faceted nature of human abilities (p. 147)."

Albert Einstein was another individual with a great mind for spatial and mathematical reasoning. Einstein developed his language skills somewhat slowly, and he had some difficulties in schools as a youngster, but these troubles may have been due to any number of reasons, including the fact that Einstein was a Jewish boy who at one point attended a Catholic school (AIP, 2004).

Einstein's wish was that, following death, his brain would be made available for scientific study – and indeed it was. In the book *Driving Mr. Einstein*, Michael Paterniti (2001) describes the strange odyssey of that brain following its removal by Princeton University pathologist Dr. Thomas Harvey. In its final journey to date, Harvey and the author traversed the U.S. with Einstein's brain enclosed in a formaldehyde filled Tupperware container, in the trunk of an old Buick Skylark. Ultimately, it was returned to Einstein's rightful heir, his daughter.

Over the years Harvey never followed through on his promise to study the brain and publish his findings in scientific outlets. However, he did share bits of it with researchers from time to time.

The outward appearance of Einstein's brain was not at all different from other brains, except in a few key aspects. Most notably, the parietal lobes, which are implicated in spatial and mathematical reasoning, were enlarged, whereas certain other areas of the brain were somewhat smaller than average (Pinker, 2002; Witelson, Kigar, & Harvey, 1999).

Further researches into brain anatomy, and perhaps more promising, brain functioning as revealed by scanning techniques, may lead to new insights about specific aspects of intelligence – as Spearman himself suspected in the very early twentieth century.

Measuring Intelligence

Binet and Simon (1905) devised the first intelligence tests as a means of identifying students who were at risk for poor performance in school. Thus their tests were used for assessment for special education referrals. Children who scored low on such

tests could be given special assistance, including remediation or practice working on items similar to those they missed. Test items consisted of a variety of different kinds of mental tasks – as they still do today. The items on the Binet-Simon tests were ordered in terms of difficulty. Although it was possible to obtain total scores for individuals, Binet did not believe that intelligence represented a single ability. Binet fretted about the possibility of misusing test scores, and the related dangers of labeling (Gould, 1996).

Despite Binet's cautions, mental measurements did become a widely used educational and psychological assessment phenomenon in the early to the mid twentieth century. Louis Terman first published the Stanford-Binet intelligence test in 1916. Later revisions of this test are still in use. Following William Stern, the term intelligence quotient, or ***IQ***, became widely used as the single score that best summarized the results of the testing. This amounts to dividing the child's mental age (average age of children who obtain this score by the chronological (or actual) age, then multiplying the result by 100 (so that an average child's score is exactly 100). As an example, a 10 year old child who is performing like an 8 year old has an IQ of 80[3]:

IQ = (MA/CA) X 100 = (8/10) X 100 = 80.

One of the greatest misuses of intelligence testing was in assessing IQs of immigrants arriving at Ellis Island in the early 20th century. Because so many could not speak English, and some lacked formal education, many non-English speaking groups were assessed as feeble-minded by poorly trained test administrators. This testing was partly responsible for the passing of the Immigration Restriction Acts of 1921 and 1924, in which low quotas were set for certain groups, notably southern and eastern Europeans (Gould, 1993). Today, people would clearly view such legislation as extremely misguided if not bigoted.

Intelligence tests today are often administered by career or personal counselors who are specially trained in their proper usage. Routine testing in schools is no longer common, but intelligence testing may also be conducted by school psychologists or other qualified professionals for specific purposes: to place children in

gifted programs, or to help diagnose learning problems. When used in conjunction with other kinds of tests – for example, aptitude, achievement, or personality tests, they can be quite useful. For such purposes individually administered tests, such as the Wechsler tests or the Stanford-Binet III, are more useful and more reliable than group administered tests. Such tests usually give not only a single IQ number, but also provide scores on subtests that measure more specific abilities, such as verbal comprehension, mathematical reasoning, tests of spatial ability (as in tasks involving mental rotations), and so forth. (But note that use of subtest scores versus total scores still raises the issue of whether intelligence is a single ability or many.) Used wisely by trained professionals, intelligence tests can indeed provide useful information for the client or for parents and teachers, and abuses and misuses of test scores are much less common than they once were.

Do Highly Intelligent People Do Better in Life than Others?

IQ scores are substantially correlated with academic success, but they are quite poor, on the whole, at predicting success in life (Sternberg, 1985). There are good reasons for this finding. As might be surmised, not only intelligence, but also motivation, determination, and belief about one's abilities have quite an impact on achievement (Dweck, 1999; Terman & Oden, 1959). These variables also play a role in defining so-called "over" and "under-achievers." Traditionally, an over-achiever is a student who, because of a high level of motivation and determination, performs better in school than would be anticipated from an examination of the student's intelligence (or other) tests scores. An under-achiever, by contrast, fails to meet expectations.

Implicit Theories of Intelligence. Carol Dweck and her associates conducted a number of research studies concerning people's beliefs about their intelligence (summarized in Dweck, 1999). Dweck identified students using the concept of ***implicit theories of intelligence***, which are theories people formulate about themselves concerning their abilities. Some students become what she calls ***entity theorists***, who implicitly believe that intelligence is

a fixed and unchanging characteristic. Others she identified as ***incremental theorists***, who believe that intelligence can be increased through experience and effort.

Incremental and entity theorists among students form different motivational patterns. Incremental theorists tend to work harder at solving difficult problems – they have a ***mastery orientation*** – whereas entity theorists react with a ***helpless orientation*** when presented with highly frustrating tasks – they tend to believe that they are not capable of solving such problems and give up sooner in frustration. Students entering middle school who held an entity theory of intelligence were at a disadvantage and they underachieved. Even entity theorists with high confidence in their intelligence did poorly, whereas incrementalist students with low confidence in their intelligence had higher actual achievement. The entity theorists underachieved because they held a helpless orientation and the incremental theorists overachieved because they had a mastery orientation (Henderson & Dweck, 1990). In Albert Bandura's (1997; also see Chapter 11) terms, it is a sense of ***self-efficacy*** (mastery orientation in this case; a belief that effort would pay off) rather than confidence (in one's fixed abilities) that was the key variable in the higher achievement of the incrementalists.

Emotional Intelligence. Some of us may wonder how it can be that certain individuals who are supposed to be so smart can act so dumb! Having a high IQ is no guarantee of success, especially when one is removed from a purely academic setting. A person can be very bright in some ways, and yet be quite clueless when it comes to sizing up others, having good relations with other people, and for that matter, really having a good understanding of one's self and the ability to handle one's own emotions.

Cantor and Kihlstrom (1987) wrote about ***social intelligence***, or the ability to successfully understand and evaluate other people and handle oneself in social situations. The concept of social intelligence has been expanded more recently, and is now called ***emotional intelligence*** (Salovey & Mayer, 1990; Goleman, 1995; Mayer & Salovey, 1997). Part of emotional intelligence involves the ability to regulate one's own emotions; another part is simply

the ability to get along with others. Both abilities involve perception, sensitivity, and understanding. A person who is emotionally intelligent can regulate their own emotional highs and lows, is sensitive to the moods of others and makes appropriate responses in social situations. Emotional intelligence is thus highly related to success in service oriented businesses, or in any realm that involves working closely with others.

But is it really sensible to call such abilities "intelligence?" Such social skills are not at all close to what traditional intelligence tests measure, although they may overlap some of Gardner's all-encompassing facets of intelligence in certain respects; mainly his interpersonal and intrapersonal intelligences. Perhaps these skills come closer to personality attributes, such as the traits of "agreeableness" and "conscientiousness" (see Chapter 14). But whatever one calls it, in dealing with people emotional intelligence is as important as any other ability; in fact it is of the utmost importance for success in many areas of life.

Some Tentative Conclusions Regarding the Number and Nature of Cognitive Abilities

Traditional disagreements about the number and nature of intellectual abilities have not entirely been resolved. In fact, there are more divergent view today than ever before on such matters. Data can be gathered and analyzed in different ways to provide at least partial support of almost every position. But disagreements can be minimized by recognition that:

1. In the case of traditional intelligence measures, viewing the controversy in terms of different levels of analysis (per the hierarchical models) provides a meaningful compromise between one, few, or many factors of intelligence. Overall measures of general intelligence (that is, of *g*) *are* useful; they are especially predictive of general academic achievement, and also can be useful in career counseling; specifically, in assessing aptitude for mentally challenging careers (along with other factors). On the other hand, measurements of more specific cognitive abilities can predict more specific outcomes – as was seen in discussing Ledyard Tucker's and Albert

Einstein's spatial/mathematical skills, which made them particularly well-suited for their chosen careers. Cases like these point to the importance of considering multiple factors and measures of intelligence. Even more extreme examples of savants, or geniuses in very specialized areas, point not only to the importance of looking at multiple factors of intelligence, but these results also suggest (per Howard Gardner's research) that different brain mechanisms may be involved in each such skill.

2. Looking beyond traditional measures provided by IQ tests, the choice of multiple facets of intelligence appears to be partly a matter of utility and preference. Does one prefer Sternberg to Gardner, or vice versa? Both have very interesting and researchable conceptions of intelligence. Given the present state of knowledge, there appears to be no absolute, objective way to distinguish between them. Both can lead to productive research, and both may prove to be practically useful; indeed, they may even prove reconcilable as "different parts of the same elephant." Emotional intelligence has also proven to be a useful concept – whether or not one considers this to be "intelligence" in the traditional sense appears to be a largely semantic question – perhaps it hardly matters in the long run.

Views on Intelligence: Science or Cultural Philosophy?

Many notable pioneers in the history of intelligence testing were Britons, and of these, many were also of the gentry, as some of their titles clearly indicate in the illustrious list of names that includes Sir Francis Galton, Charles Spearman, Sir Cyril Burt, Sir Godfrey Thompson, and Hans Eysenck. All of these people have in common a strong advocacy of a single, general factor of intelligence. Although Arthur Jensen is an American, he was trained in the "British school," and was greatly influenced by these British psychologists.

Thurstone and his intellectual descendents, on the other hand, seem to represent an "American school" of thought as regards intelligence, which Thurstone saw as not a single ability, but many different kinds of mental skills. Arguably, there are subtle or hidden cultural beliefs lurking behind the science that might (consciously or unconsciously) lead these researchers to their different positions.

Britain has traditional been a more structured society in terms of social class. Prior to the twentieth century (in which vast social changes took place – especially following the second World War), the wealthy British upper class was supported by a servant class, and class mobility was extremely limited: one remained in the class of one's birth, regardless of education, wealth, or fortune. Perhaps the notion that intelligence is a single, fixed entity appealed to those in the upper classes, who presumably score higher on the whole – but who also have had unequalled social and educational opportunities. In a darker vein, such beliefs in the innate differences between classes could potentially be used by the few to oppress the many.

On the other hand, America is (or at least was, traditionally) a place in which one's place in society is determined by one's accomplishments to a much greater extent than by one's birthright. Part of Americans' implicit mythos can be found in beliefs that all one needs is ambition and enterprise to succeed (the "Horatio Alger" myth), that one can "pull oneself up by one's own bootstraps," and that "anyone can grow up to be president." Aren't such beliefs congruent with the thought that everyone must have some special talent that they could draw upon to help them to succeed if they only try hard enough? And perhaps even more than Americans, Asian students tend to believe that motivation, effort, and hard work are more important than native ability in defining intelligence (Stevenson and others, 1990).

When taken to extremes, both viewpoints are easy to criticize. But it is well to be mindful that scientists are human beings, each with their own biases – and that these biases may drive not only their ideas, but their different interpretations of the same data.

What Factors Influence the Development of Intelligence?

Most of the research on how intelligence develops utilizes overall measures of IQ. Although the psychometric tradition of measuring intelligence provide the means to assess this trait, this line of research tells us little about the psychological and physiological mechanisms underlying it. As with virtually all psychological traits and abilities, intelligence is assumed to be determined in part by heredity, influenced to some extent by experience and learning, but moreover, is affected by the interaction between these facets of nature and nurture.

Gross Anatomy and Physiology

At a more anatomic and physiological level one may ask whether intelligence is related to brain size, or to the number of neurons and synapses within the brain; or whether it is related to the speed of neuronal transmission. Regarding the latter, many if not most intelligence test items can be solved by most adults given sufficient time to study these problems; hence, speed of thought might indeed be a factor in scoring well on such tests (time is a factor in most tests). Vernon (1994) and Jensen (1982) both presented evidence of moderate to strong correlations between IQ and simple reaction time – an idea that goes back to Galton in the nineteenth century (Gregory, 2013). Structurally it was earlier seen that Einstein's brain was, overall, no larger than the average brain, yet one area was significantly more developed – the one that had to do with spatial-mathematical relations.

Early theorists in psychology such as James McKeen Cattell and William Wundt (see Gregory, 2013) thought that quick reaction times were associated with intelligence, or in other words, intelligence conceived as swiftness of thought was believed to be correlated with swiftness of physical response. Some later theorists (e.g., Eysenck, 1994) also believed that higher intelligence was associated with greater activity of brain waves (average evoked potentials, or AEP). However, earlier research on the latter (Ertl &

Schafer, 1969) was evidently flawed, and subsequent research has shown correlations among IQ and AEP to be modest, though sometimes statistically significant (Jensen, 1980). Also, correlations of IQ with simple reaction times are at best moderate (in the -.30 to -.40 range; Jensen, 1982).

Genetics: Twin and Adoption Studies

Anatomical and physiological studies don't reveal whether neurological differences in brain function are due to heredity, environment, or to the interaction between the two. But the most impressive evidence for the heredity side of the argument comes from studies of twins and adoptions. Identical twins reared in the same home, similar in both genetics (they have, in fact, identical genes) and environment, have correlations between IQ scores in the .80s. The correlations drop somewhat to slightly above .70 on average for identical twins who are reared apart – yet they are still higher than for fraternal twins (who do not share the same DNA) who are reared together, for which the average correlation is around +0.60 (McGue and others, 1993).

Based on comparisons of twin and adopted children's correlations with IQ, and comparing these with controls, including fraternal twins reared apart or together, some psychologists have attributed approximately 50% of the shared statistical variance in intelligence test scores to genetic influences. ***Heritability*** is the term used to describe this portion of variance. However, this number is in itself a statistical average based on a number of different studies, each of which gives a somewhat different number, and the term can be misleading. A heritability coefficient of .50 *does not imply* that half of one's intelligence is due to genetic influence – such an assertion has little meaning, but especially when applied to a given individual (indeed, statistical averages themselves say next to nothing about a given person). But also, scores on intelligence tests as well as other measures of "intelligent" behavior simply cannot be neatly apportioned between environmental and genetic influences – to believe so is at best wishful thinking. Such scores on intelligence tests are *always* due to an interaction between the two forces, and truly, these sources cannot be separated; neither in principle nor in practice.

Still, these research findings do suggest that genes and therefore heredity do indeed play an important role in determining one's intelligence. Most psychologists would agree that one's measured intelligence, though not precisely fixed at any given time in life, is limited by genetic endowment: not every child can become an Einstein, Mozart, or Leonardo da Vinci. Nor can severely retarded children expect to become normal – not unless genetic scientists find new forms of gene therapy that can radically change the person's basic makeup. For the present, at least, such ideas seem indeed quite remote.

Evolutionary Psychology and Gender Differences

Men and women or boys and girls of the same age do not differ on average in overall intelligence scores. But boys and men are better on the average at spatial and mathematical skills, girls and women on verbal abilities (Halpern, 2000). Females also score higher on average on social skills; on emotional intelligence (Rosenthal and others, 1979).

Assumptions about average score differences in intellect or ability can be misleading. On the one hand, average differences tell us nothing about a given individual. One may also question whether these differences reflect trends in interest, schooling, or simple belief about one's abilities. On the other hand, if one examines the variability within each sex, differences between individuals can be much more dramatic than the average difference between genders: there are many men who are very "hi verbs," and women who excel at math – and vice versa.

Some differences between the sexes might be explained by cultural traditions and practices. As an example, by tradition, in the past girls in the U.S. were not encouraged to excel in math and science. This may be far from true today, especially among the well-educated segments of our population, and indeed, the gender-gap in test scores has narrowed somewhat in recent years.

The evolutionary case for gender differences in spatial abilities (e.g., Tooby & DeVore, 1987) assumes that in earlier civilizations men as hunters, who roved far from their home territory, developed greater spatial skills than women in order to better orient themselves geographically. As hunters, men may have

communicated more by pointing and signaling than by direct communication so that they would not frighten game. Perhaps this is why men do better at mental rotation tasks (related to map reading) on intelligence tests than women.

But as gatherers may have developed their own specialized spatial skills: namely, the ability to locate plant species and other specific objects in the environment (Silverman & Phillips, 1998). (How many men would agree that their wives can better recall the location of small objects about the house?)

Women do better than men on tests of verbal memory and verbal fluency than men but just why such differences might have arisen from an evolutionary perspective exist remains speculative (Kimura, 2002). However, differences in verbal abilities favoring women and in spatial abilities favoring men do appear to be correlated with the relative presence of the hormones estrogen and testosterone, respectively (Kimura, 1999). But to reiterate, differences on average between the sexes in verbal, mathematical, and spatial abilities are small in comparison to differences within each sex and researchers still disagree regarding the importance of evolution versus culture (nature/nurture once again!).

Environmental Influences on the Development of Intelligence

Studies suggest that extremely impoverished environments, with a paucity of interaction and stimulation can adversely affect intellectual development. Lack of stimulation at certain sensitive periods of development leads to emotional deficits in neglected children. To an extent, similar results obtain with intelligence. On the other hand, some research suggests that enriched environments in young children can increase intelligence test scores in the early years, although the long-term effects are less well established (Ramey & Ramey, 1998).

Animal studies have shown that enriched versus impoverished environments in rats lead to impressive increases in the development of the brain's cortex (Rosenzweig, 1984; also see Kolb & Whishaw, 1998). (An enriched environment included more "toys" and other objects for the animals to explore.) Can enriched environments affect human brains as well?

Evidence on the effects of enriched environments is indirect and correlational, because, of course, one cannot randomly assign humans to experimental and control groups over long periods of time. But numerous research studies strongly suggest that this is the case. Not all of these studies measured intelligence directly, but perhaps indirectly, by increasing motivation (and therefore achievement):

- J. McVicker Hunt (1982) observed attention deprived children in an Iranian orphanage. In an experimental intervention treatment program he found that children who were attended to and, in particular, given language instruction, improved not only these particular skills, but also became more sociable and "adoptable."

- Head Start educational programs, developed for early intervention for "at risk" students (students from impoverished neighborhoods) have been enormously successful (Campbell & Ramey, 1994; Ramey & Ramey, 1998). The programs involve special preschool programs, and they include parent participation. These programs greatly enhance students' academic success in early schooling, and to some extent later motivation to continue their education (not dropping out or requiring special education; Lazar & Darlington, 1982).

- Children's IQ scores have increased significantly over the years in all countries of the world (Flynn, 1999; Neisser & others, 1996). There are many possible reasons for this increase – including better education and improved nutrition – but all of these potential causes are environmental.

- Enriched home environments are associated with greater school motivation and achievement (Bradley and others, 1989; Gottfried, Fleming, & Gottfried, 1998). (Home environment variables encompass family support of intellectual stimulation, control of television watching, music or dance lessons, and similar enrichment strategies.)

- Regarding so-called racial differences in measured IQ, Arthur Jensen (1969) began a long-running controversy in education and psychology by noting the lower average test scores for minorities, along with his assumption that such differences are due to race. (Note once again, as above, that psychologists today as a whole do not recognize race as a viable *biological* construct.) But Scarr and Weinberg (1976) found that African-American children who were adopted into White families with higher than average levels of education and income scored higher than average on intelligence tests, which suggests that environmental factors were a decisive influences.

Some Practical Advice for Parents. What can a parent do to assist children in their intellectual development? The above studies suggest the obvious: children can benefit from enriched environments, early schooling, and parental encouragement toward learning. Certainly reading to children and encouraging them to read when very young is helpful. But can parents push their children too hard? According to Sandra Scarr (1984) they can, but with diminishing returns in exchange for their efforts. While it is good to provide children with enriched environments, parents can go too far by attempting to accelerate their children's development by hiring coaches or trainers in the early years (Quart, 2006). While it may be true that certain, notable geniuses were indeed pressured to excel by their parents (e.g., Mozart; John Stuart Mill, both by their fathers), the same result is questionable for children who show no signs of such genius early on; and the psychological effects (later rebellion and/or neurosis) can be devastating.

Changes in Cognitive Functioning Over Time

From the earliest days of intelligence testing researchers correctly assumed that cognitive functioning increased over time during the school years. Findings indicated that intelligence (not IQ, which is age-adjusted, but overall cognitive functioning) peaked at about ages 18 to 21. But in the early part of the twentieth century it was believed that mental abilities began to slowly decline after that.

This conclusion was based on faulty data gathered from cross-sectional samples of people tested at different ages during the same time period. A problem with cross-sectional research (Chapter 2) is that the data fail to account for cohort differences, and therefore missed that fact that educational opportunity had increased significantly, so that the younger groups scored higher due to their superior educational backgrounds. Longitudinal research (tracking the same cohorts over time) showed a quite different picture, although it took many years to properly accumulate such data. Nancy Bayley (1966), basing her findings on a well-tracked cohort from the Berkeley Growth Study, concluded that for many, intellectual functioning continued to grow until at least the mid-thirties (the current age of the cohort).

But even longitudinal studies have their limitations by studying only a single group or cohort. There are many uncontrolled variables that can affect the average scores of a cohort; for example, having one's education interrupted by a call to go to war, or extreme economic fluctuations due to a boom, recession, or depression. K. Warner Schaie did painstakingly detailed research in a project known as the Seattle Longitudinal Study (Schaie, 1988; 1996) using the cross-sequential method, which combines cross-sectional and longitudinal methods (recall Fig. 2.1 from Chapter 2). Schaie showed that cognitive abilities tend to increase for most people until around the late 50s, after which they begin to *slowly* decline. But for most people significant declines from the peak years occur after about age 80.

Broken down into more specific abilities, numeric abilities begin to decline about a decade earlier than general ability. However, averages are not the real story, which is that *individuals* can grow or decline throughout adulthood. Presumably, growth occurs with continued learning and through the process of mental stimulation. Decline can occur for a number of reasons, including illness; but also from simple lack of exercising of one's "mental muscle" (Schaie, 1994).

Intelligence: In Search of a Working Definition

After years of work in the area of intelligence Sternberg appears to have tempered his initial pessimism regarding psychology's understanding of the construct (per the opening chapter quote). After considering previous attempts to define intelligence, Sternberg (1997, p. 1030) offered the following:

> *Intelligence comprises the mental abilities necessary for adaptation to, as well as shaping and selection of, any environmental context.*

This definition may sound simple, but there is much to it. Consider each part separately:

a. Intelligence comprises the ***mental abilities*** . . .

   This definition is in line with tradition in that it stresses intelligence as necessarily "mental." It therefore does not consider certain other specialized abilities as appropriate, such as kinesthetic ability.

b. . . . necessary for ***adaptation to*** . . . any environmental context.

   The "adaptation to" portion is consistent with older definitions; compare with Wecshler's definition at the beginning of this chapter. It stresses adaptive behavior – even thought most standardized tests are arguably very weak on this facet.

c. . . . as well as ***shaping and selection of***, any environmental context.

   It isn't enough to merely adapt; one must also be able to select and/or shape one's environment. (If you don't like your situation, change it or get out!)

d. . . . ***any*** environmental context.

> Emphasizing the word "any" truly implies flexibility. If an "intelligent" person is placed in a new or strange environment (another cultural setting, perhaps), he or she ought to be able to adapt to it, or at least to use her or his mental powers to attempt to do so.

Note that this definition says nothing about how intelligence is, or ought to be, measured. Sternberg believes that, although the essential attributes for intelligence transcend cultures, the means of evaluating them are strongly dependent on one's cultural context: "The *processes* of intelligence are universal but their *manifestations* are not" (2004, p. 336, emphasis added). Consequently, he does not believe that it is possible to construct a "culture free," or even "culture fair," tests of intelligence despite earlier attempts to do so. Instead, he believes, psychologists should construct tests that are ***culture-relevant***.

Sternberg is also an advocate of ***lifelong learning***; he does not believe that learning ceases with the termination of formal education or technical training. The definition he gives here seems to encompass that particular kind of leaning. At the same time, this definition seems quite consistent with his notion of successful intelligence and its three components: Analytic, creative, and practical.

*****

For Thought and Discussion

1. Share with the class, if you can, a time in which someone made you feel stupid ("extra credit" if this person was a teacher!). How did you deal with this situation?
2. Look over Thurstone's seven primary mental abilities (Table 5.1). Try to think of other abilities that are important aspects of "intelligence" that are not listed here.
3. Try rating yourself on a scale of 1-10 for each of Gardner's eight aspects of intelligence. (Braver students can also share some of these with the class.)
4. Do the same (as in number 3) for Sternberg's three dimensions of successful intelligence.
5. As another self-evaluation exercise, do you tend to think of yourself as one of Dweck's "entity theorists" or "incremental theorists"?
6. Sandra Scarr believes that parents are wrong to attempt to raise "super-children;" she really believes that it is fine to be a "good enough" parent and to a very great extent, let kids be kids. What is your opinion on the duties and responsibilities of parenting, especially as regards children's intellectual growth?
7. For sharing with the class, think of someone you know who is very apt or intelligent in one area (using any of the definitions of intelligence encountered in this chapter) but very inept in some other area.
8. What are some of the weaknesses of factor analysis as a means of determining the number and nature of intellectual abilities?
9. Try to think of some possible arguments that an evolutionary psychologist might use to explain the apparent difference between men and women on verbal abilities (women on average score higher on verbal memory and verbal fluency).

*****

Notes

1. Sternberg (1988, p. 6).
2. Boring (1923).
3. Intelligence quotients are no longer used due to statistical problems with using such ratio data across ages (Pinneau, 1961). Instead, data are normed within age groups so that the average based on large norming samples is set to 100.

*****

References

American Institute of Physics (2004). *Einstein: Impact and image*. [Online]. Available: www.aip.org/history/einstein. [Accessed June 8, 2006.]

Bandura, A. (1999). Social cognitive theory of personality. In L. Pervin and O. P. John (Eds.), *Handbook of personality* (2nd Ed., pp. 154-196). New York: Guilford Press.

Bayley, N. (1966). Learning in adulthood: The role of intelligence. In H. J. Klausmeier & C. W. Harris (Eds.), *Analysis of concept learning*. New York: Academic Press.

Beirne-Smith, M., Patton, J. R., & Kim, S. H. (2005). *Mental retardation: An introduction to intellectual disabilities* (7th Ed.). Englewood Cliffs, NJ.: Prentice-Hall.

Binet, A., & Simon, T. (1905). Methodes nouvelles pour le diagnostic du niveau intellectuel des anormaux. *Anee Psychologique*, *11*, 191-244.

Boring, E. G. (1923, June 6). Intelligence as the tests test it. *New Republic*, 35-37.

Bradley, R. H., Caldwell, B. M., Rock, S. L., Ramey, C. T., Barnard, D. E., Gray, C., Hammond, M. A., Mitchell, S., Gottfried, A., Siegel, L., & Johnson, D. L. (1989). Home environment and cognitive development in the first 3 years of life: A collaborative study involving six sites and three ethnic groups in North America. *Developmental Psychology*, *25*, 217-235.

Campbell, F. A., & Ramey, C. T. (1994). Effects of early intervention on intellectual and academic achievement: A follow-up study of children from low income families. *Child Development*, *65*, 684-698.

Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology*, *54*, 1-22.

Cattell, R. B. (1987). *Intelligence: Its structure, growth, and action*. Amsterdam: New Holland.

Dorans, N. J. (2004). Ledyard R Tucker [Interview]. *Journal of Educational and Behavioral Statistics*, *29*, 145-151.

Dweck, C. S. (2000). *Self-theories: Their role in motivation, personality, and development.* Sussex, UK: Taylor & Francis.
Ertl, J. P., & Schafer, E. W. P. (1969). Brain response correlates of psychometric intelligence. *Nature, 223,* 421-422.
Eysenck, H. J. (1994). EEG evoked potentials. In R. J. Sternberg (Ed.), *Encyclopedia of human intelligence*. New York: Macmillan.
Flynn, J. R. (1999). Searching for justice: The discovery of IQ gains over time. *American Psychologist, 54*, 5-20.
Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.
Gardner, H. (1993). *Multiple intelligences: The theory in practice*. New York: Basic Books.
Goleman, D. (1995). *Emotional intelligence*. New York: Bantam Books.
Gottfried, A. E., Fleming, J. S., & Gottfried, A. W. (1998). Role of cognitively stimulating home environment in children's academic intrinsic motivation: A longitudinal study. *Child Development, 69,* 1448-1460.
Gould, S. J. (1996). *The mismeasure of man* (Rev./expanded Ed.). New York: W. W. Norton.
Gregory, R. J. (2013). *Psychological testing: History, principles, and applications* (7th Ed.). New York: Pearson.
Guilford, J. P. Structure of the intellect. *Psychological Bulletin, 53,* 267-293.
Halpern, D. (2000). *Sex differences in cognitive abilities* (3rd Ed.). Hillsdale, NJ: Erlbaum.
Henderson, V., & Dweck, C. S. (1990). Achievement and motivation in adolescence: A new model and data. In S. Feldman & G. Elliott (Eds.), *At the threshold: The developing adolescent*. Cambridge, MA: Harvard University Press.
Horn, J. L. (1994). Theory of fluid and crystallized intelligence. In R. J. Sternberg (Ed.), *Encyclopedia of human intelligence*. New York: Macmillan.
Hunt, J. M. (1982). Toward equalizing the development opportunities of infant and preschool children. *Journal of Social Issues, 38,* 518-530.

Jensen, A. R. (1969). How much can we boost IQ and scholastic achievement? *Harvard Educational Review*, *39*, 1-123.
Jensen, A. R. (1982). The chronometry of intelligence. In R. J. Sternberg (Ed.), *Advances in the psychology of human intelligence.* Hillsdale, NJ: Erlbaum.
Kaiser, H. F. (1970). A second generation Little Jiffy. *Psychometrika*, *35*, 401-415.
Kimura, D. (1999). *Sex and cognition*. Cambridge, MA: Massachusetts Institute of Technology Press.
Kimura, D., & Clarke, P. (2002). Women's advantage on verbal memory is not restricted to concrete words. *Psychological Reports*, *91*, 1137-1142.
Kolb, B., & Whitshaw, I. Q. (1998). Brain plasticity and behavior. *Annual Review of Neuroscience*, *49*, 43-64.
Lazar, I,, & Darlington, R. (1982). Lasting effects of early education: A report from the Consortium for Longitudinal Studies. *Monographs of the Society for Research in Child Development*, *47*(2-3, Serial No. 195).
Mayer, J. D., & Salovey, P. (1997). What is emotional intelligence? In P. Salovey & D. J. Sluyter (Eds.), *Emotional development and emotional intelligence: Educational implications.* New York: Basic Books.
McGue, M., Bouchard, T. J., Jr., Iacono, W. G., & Lykken, D. T. (1993). Behavior genetics of cognitive ability: A lifespan perspective. In R. Plomin & G. E. McClearn (Eds.), *Nature, nurture, and psychology*. Washington, DC: American Psychological Association.
Neisser, U., Boodoo, G., Bouchard, T. J., Boykin, A. W., Brody, N., Ceci, S. J., Halpern, D. F., Loehlin, J. C., Perloff, R., & Sternberg, R. J. (1996). Intelligence: Knowns and unknowns. *American Psychologist*, *51*, 77-101.
Paterniti, M. (2000). *Driving Mr. Albert: A trip across America with Einstein's brain*. New York: Dell.
Pinker, S. (2002). *The blank slate: The modern denial of human nature*. New York: Penguin.
Pinneau, S. R. (1961). *Changes in intelligence quotient from infancy to maturity*. Boston: Houghton-Mifflin.
Quart, A. (2006). *Hothouse kids: The dilemma of the gifted child.*

New York: Penguin.
Ramey, C. T., & Ramey, S. L. (1998). Early intervention and early experience. *American Psychologist, 53,* 109-120.
Rosenthal, R., Hall, J. A., Archer, D., DiMatteo, M. R., & Rogers, P. L. (1979). The PONS test: Measuring sensitivity to nonverbal cues. In S. Weitz (Ed.), *Nonverbal communication* (2nd. Ed.), New York: Oxford University Press.
Rosenzweig, M. R. (1984). Experience, memory, and the brain. *American Psychologist, 39,* 365-376.
Salovey, P., & Mayer, J. D. (1990). Emotional intelligence. *Imagination, Cognition, and Personality, 9,* 185-211.
Scarr, S. (1984, May). What's a parent to do? A conversation with E. Hall. *Psychology Today,* 58-63.
Scarr, S., & Weinberg, & Weinberg, R. A. (1983). The Minnesota Adoption Studies: Genetic differences and malleability. *Child Development, 54,* 260-267.
Schaie, K. W. (1988). Variability in cognitive functioning in the elderly. In M. A. Bender, R. C. Leonard, & A. D. Woodhead (Eds.), *Phenotypic variation in populations*. New York: Plenum.
Schaie, K. W. (1994). The life course of adult intellectual abilities. *American Psychologist, 49,* 304-313.
Schaie, K. W. (1996). *Intellectual development in adulthood: The Seattle Longitudinal Study*. Cambridge, England: Cambridge University Press.
Silverman, I., & Phillips, K. (1998). The evolutionary psychology of spatial sex differences. In C. Crawford & D. L. Krebs (Eds.), *Handbook of evolutionary psychology*. Mahwah, NJ: Erlbaum.
Spearman, C. (1904). General intelligence, objectively determined and measures. *American Journal of Psychology, 15,* 201-293.
Sternberg, R. J. (1985). Beyond IQ: *A triarchic theory of human intelligence*. Cambridge, England: Cambridge University Press.
Sternberg, R. J. (1988). *The triarchic mind: A new theory of human development*. NewYork: Penguin.
Sternberg, R. J. (1997). The concept of intelligence and its role in lifelong learning. *American Psychologist, 52,* 1030-1037.

Sternberg, R. J. (2004). Culture and intelligence. *American Psychologist, 59*, 325-338.
Sternberg, R. J., & Detterman, D. K. (Eds.). (1986). *What is intelligence? Contemporary viewpoints on its nature and definition.* Norwood, NJ: Ablex.
Sternberg, R. J., Grigorenko, Elena L., & Kidd, K.K. (2005). Intelligence, reace, and genetics. *American Psychologist, 60*, 46-59.
Stevenson, H. W., & Lee, S.-Y. (1990). Contexts of achievement: A study of American, Chinese, and Japanese children. *Monographs of the Society for Research in Child Development, 55*, (Serial No. 221, Nos. 1-2).
Terman, L. M. (1916). *The measurement of intelligence*. Boston: Houghton-Mifflin.
Terman, L., & Oden, M. H. (1959). *Genetic studies of genius: The gifted group at midlife*. Stanford, CA: Stanford University Press.
Thurstone, L. L. (1938). Primary mental abilities. *Psychometric Monographs*. No. 1. Chicago: University of Chicago Press.
Tooby, J., & DeVore, I. (1997). The reconstruction of hominid behavioral evolution through strategic modeling. In W. G. Kinzey (Ed.), *The evolution of human behavior*. New York: State University of New York Press.
Vernon, P. A. (1994). Reaction time. In R. J. Sternberg (Ed.), *Encyclopedia of human intelligence*. New York: Macmillan.
Vernon, P. E. (1971). *The structure of human abilities*. (Rev. Ed.). London: Methuen. (Originally published in 1950.)
Wechsler, D. (1944). *The measurement of adult intelligence* (3rd Ed.). Baltimore: Williams & Wilkins.
Witelson, S. F., Kigar, D. L., & Harvey, T. (1999). The exceptional brain of Albert Einstein. *Lancet, 353*, 2149-2153.
Zigler, E. (1998). Should school begin at age 3 for American children? *Journal of Developmental and Behavioral Pediatrics, 19*, 37-38.